

Crowd Orchestration – An EPS@ISEP 2021 Project

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ABSTRACT

The European Project Semester (EPS) is a multicultural and multi-disciplinary project-based learning semester offered by a network of providers, including the Instituto Superior de Engenharia do Porto (ISEP). In the spring of 2020/2021, five EPS@ISEP students from different areas of studies and countries – Portugal, Romania, Poland and France – teamed up. Given the disorganization and overcrowding affecting the experience of attendees at large events, the team decided to create a Crowd Orchestration solution for large outdoor festivals. To this end, the team designed “ScanGo” with real time alerts about the number of people in predefined areas, suggestion of alternative activities within the event or indication of the best route to go from one stage to the another. This way, ScanGo also intends to minimize the effects of the undergoing pandemic, allowing people to safely experience open air festivals. This paper reports the different stages of the teamwork, encompassing

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the preliminary studies and the design of ScanGo, followed by the development and test of a proof of concept prototype.

CCS CONCEPTS

• **Applied computing**; • **Collaborative learning**; • **Social and professional topics**; • **Computational science and engineering education**;

KEYWORDS

Engineering Education, Project-based Learning, Multicultural and Multidisciplinary Teamwork, European Project Semester

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1 INTRODUCTION

The European Project Semester is a program for international students who have completed at least two years of study. Designed

by Arvid Andersen in 1995, especially for engineering students, EPS combines problem based learning with project related courses [6]. Adopted by a network of 19 European universities, including the School of Engineering (ISEP) of the Polytechnic of Porto, the goal of this semester program is to promote teamwork, motivating students to work together in the design and development of an innovative product, while improving communication skills and getting familiar with different cultures, and work methods.

In the 21st century, large outdoors and indoors festivals have become very popular. However, attendees lack real time information about the location, available capacity and details of ongoing concerts, activities and services. In service areas people often have to wait in long queues to go to the toilet or buy food and drinks. Moreover, with the undergoing pandemic, attendees wish to avoid crowds and know beforehand the number of people in a given zone. Controlling crowds during festivals is a very difficult task, even with a large support staff. For this reason, five students from four different countries (Portugal, France, Romania and Poland), and with diverse study backgrounds (mechanical engineering, biotechnology, industrial design engineering, business and technology, and packaging engineering), decided to create a novel product to minimize these problems. The project brief specified a set of broad requirements namely the adoption of ethical and sustainable practices, use of open source software, recycled or repurposed materials, the compliance with the applicable European Union (EU) directives and International System of Units, and a maximum budget of 100 € for the prototype. The main mission of the team was to embrace teamwork, create a positive work environment and achieve all established goals. The proposed solution – ScanGo – aims to support event organizers and attendees with timely directions to avoid overcrowding and make the whole experience easy, enjoyable and safe. With the ScanGo mobile application and device, attendees receive real-time information about ongoing concerts, crowd density in designated areas and incentives to attend alternative activities.

This paper outlines the aims of the project and the functionalities of the device. Next, it describes ScanGo in detail, including its design, development, testing and, finally, a summary of the project and personal achievements.

2 PRELIMINARY STUDIES

This section goes over related products and systems, ethics, sustainability aspects and marketing to identify the most crucial requirements and design the product according to the rules of sustainable development and ethics.

2.1 Related Works

Related products are the crowd management devices and systems that already exist on the market intended to enhance the experience of the public. The research identified four types of crowd orchestrating products:

- The airplane boarding system has different advantages to orchestrate the crowd effectively: (i) boarding information is projected on the ground; and (ii) passport checking queue is projected by the person who checks the passports, using colorful blocks, to depict and maintain the proper social

distance. As a result, social distance is respected, personal space is preserved and people find easily their way [10].

- The Orange Belgium System provides a real-time data stream of the location of mobile phones connected to its network. It returns the density of people within the specified zone, allowing the city to monitor the crowd in real time. The goal is to control the number of people in crowded places [8].
- Canon has developed a crowd counting technology that returns the number of people in an area instantaneously to be deployed at sites where congestion is expected to occur. It monitors threshold capacities (tracks how many people are in a designated area) for security control [2].
- The integration of digital displays and mobile apps is used in crowd-intelligent path finding. These components help guests to make smart decisions when moving through the space [3].

2.2 Sustainability

Sustainability is a very important and complex concept to consider since the product must be as sustainable as possible to improve the quality of life of its users without harming the environment. In this sense, eco-efficiency is a concept used by companies for a sustainable development and considers environmental and human needs. The main objective is to protect all life on Earth by using natural resources parsimoniously and recycling materials.

The United Nations (UN) defined 17 Sustainable Development Goals to be achieved by 2030 [5]. To contribute to these goals, the team opted to follow the Cradle to Cradle, ISO 14062 and ISO 14001 certifications and use a solar panel for power. On the other hand, the selected materials are Aluminum and Polypropylene. While Aluminum is non-toxic to users and the environment (does not have negative quality either in the air, on the ground or water and does not burn in the event of a fire), polypropylene is recyclable [11].

Socially, it is important to reiterate that prospective employees should be treated in a polite and respectful manner and benefit those who manage to achieve the goals of the ScanGo company.

2.3 Ethics

The design of the product considered ethical values and current EU directives. Ethics and professional deontology provide a set of values to govern the prospective company. To build a good reputation, the company has to be honest with both the customers and the competition. By using ethical marketing, the product brand will provide the public with understandable correct information about the product. Recognition of reliability and dependability is another priority. Taking into account environmental ethics, the solution should have an eco-friendly design, balancing the social, economic and environmental aspects. The promotion of the product should focus on the well-being of the user. The ScanGo device and logo were checked to verify that they did not infringe any intellectual property rights. All sources used in this work were referenced. General ethical and deontological issues were carefully considered throughout the project, as they are key factors in any global business.

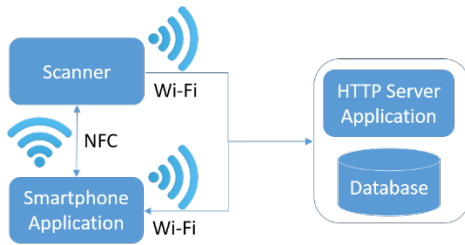


Figure 1: Block diagram

Moreover, the project complies with the EU Machine Directive (MD), Electromagnetic Compatibility Directive, Low Voltage Directive, Radio Equipment Directive and the Restriction of Hazardous Substances EU directives.

2.4 Marketing

The festival market has been growing steadily for several years and will continue to do so in the coming years [12]. The decision to use Near Field Communication (NFC) instead of the Quick Response (QR) codes differentiates ScanGo from the competition.

The analysis of the Political, Economic, Social, Technological, Environmental and Legal [1] factors highlights several points: increase the safety of festival-goers by orchestrating the crowd and avoid overcrowding, facilitate the participation in the cultural economy, improve attendee experience, using NFC, reduce the environmental impact by offering rental and reusing packaging and, finally, adapt to official restrictions. The Strengths, Weaknesses, Opportunities, Threats analysis showed that the product targets a broad spectrum of users. As a new brand, it needs to establish itself in the European market to stay ahead of competition.

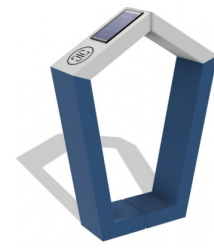
ScanGo has economic objectives (to contribute to the economy of the festivals and the country by bringing in foreign festival-goers for tourism and consumption), ecological objectives (to offer a rental service, which encourages the use of the scanners at different festivals and the reuse of packaging for transport) and customer objectives (to improve the user experience and encourage loyalty). As a brand, ScanGo intends to offer a rental and installation service to organizers and a mobile application for attendees with a map updated in real time. Promotion should be done through social networks (about 1000 €) and a website (between 500 € and 1000 €).

3 PROPOSED SOLUTION

Based on the previous studies, the proposed solution comprises a scanning device, a mobile application and a remote server application (Figure 1). The communication between smartphone and scanner uses NFC and between scanner and remote server and smartphone and remote server uses Wi-Fi. The main objective is to increase the safety of people at outdoor festivals by avoiding overcrowding and disorganization. In this sense, the public obtains timely information, directions and suggestions for alternative activities that may be taking place.



(a) Logo



(b) Scanner 3D model

Figure 2: ScanGo

3.1 Concept

The idea behind the design is to help organizers and attendees to avoid overcrowding. The goal is to optimize the experience of attendees by reducing wait periods, suggesting the quickest and safest way to the desired destination and receiving timely information. Specifically, at festivals, people often end up missing concerts or other activities due to this lack of information and organization. This may lead to get lost from friends or wait for long periods to go to the toilet or buy foods and drinks. To interact with the device, the user places the smartphone near the scanner, which has an integrated NFC module, and, immediately, the mobile application pops in the screen for further user interaction.

3.2 Design

The designed scanner considers the human body proportions for an easy and convenient interaction. By placing two scanners back to back, the modern body of the scanner creates a pentagonal shape. The scanner is composed of three rectangular hollow pieces where the internal components are located, protecting them from the weather and ill-intentioned people. The materials selected for the structure of the scanner are aluminum and polypropylene with stabilizers to grant a better UV resistance. Both materials are recyclable and resistant. The scanner dimensions provide easy access for every user, with the total height of 130 cm. The inclination angle of 30° provides a good water flow in case of rain. Figure 2b displays the designed product.

The logo presented in Figure 2a represents a crowd of people heading in different directions. To make it as attractive as possible and capture the user's attention, the logo is simple and easy to identify. To differentiate from competitors, the color plays an important role. The final logo is multicolored, incorporating all shades of the color spectrum. This symbolizes the multiculturalism of the people in the audience.

A short, clear and original slogan promotes the product in just a few words. The chosen motto: "Find your own path!" is simple and reminds users of the basic goal of the product: to guide festival attendees in real time.

3.3 Control

The core of the scanner is the control system. It comprises an NFC module, an ESP32 microcontroller, a Light-Emitting Diode (LED) diode, a solar panel, a switch and a battery. The battery connects to the microcontroller through the built-in charge port and the solar

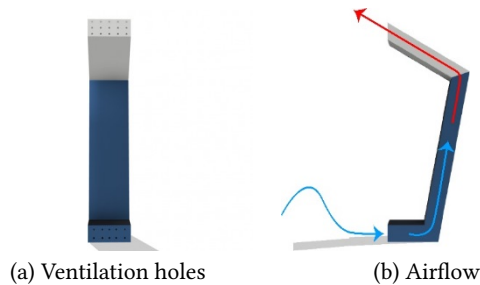


Figure 3: Solar chimney

panel through the voltage stabilizer. The 5 V solar panel regulator provides the proper voltage. The power switch is placed on the back side of the scanner.

The ESP32 counts the smartphones scanned. To do so, it connects to a remote database through the integrated Wireless Fidelity (Wi-Fi) module. The ScanGo application presents the user with a map-based interface of the festival, which is updated in real-time, and provides information on crowd density at different locations, paths to different stages, incentives for alternative activities and concerts taking place.

3.4 Structure

The structure of the scanner is in aluminum and the scanning area in polypropylene (Figure 2b).

Ground Anchors. To attach ScanGo to the ground, the team considered ground screws and angle brackets. The plan is to avoid building traditional concrete foundations. This way, the soil ecosystem remains intact and underneath infrastructures are left undamaged [9]. Despite all these advantages, the cost of ground screws is relatively high and requires specific installation equipment. The alternative is to securely attach the device to existing support structures with L-shaped metal connectors.

Solar Chimney. To take full advantage of the shape of the structure to cool the control system, the bottom and top parts of the product have holes to create a solar chimney effect (Figure 3a). The aluminum structure is tall and empty, allowing the fresh air to travel from the bottom holes and exit through the top, cooling internal components. As the hot air rises, it draws in more fresh air from the bottom, creating a passive ventilation system [4]. Figure 3b illustrates the airflow.

3.5 Packaging

Packaging will be reused to transport scanners to and from festivals as part of the renting and (un)installation service provided to festival organizers. This implies a resistant packaging solution with an easy-to-handle tape free opening/closing on the top. Figure 4 displays the packaging solution made of corrugated cardboard for increased shock resistance. The strength on the underside was reinforced to prevent damage and the “ears” on either side of the lid fit into the slots and stabilize the package. Inside, wedges made of honeycomb cardboard replace the traditional non-recyclable expanded polystyrene.

3.6 Functionalities and Services

ScanGo saves attendee time and reduces the risk of overcrowding for organizers. It offers the following functionalities to both organizers and attendees. Considering the attendees:

- The scanner connects through NFC with the smartphone.
- The ScanGo application opens on the smartphone to display the map of the festival.
- The attendee receives real-time information about the concerts, activities and the number of people in the chosen area through a map-based interface.

Regarding organizers, the multi-day scanner rental service, including transport, installation and set-up, saves time and money since needs-based rentals are free of maintenance and storage costs.

3.7 Tests

Several tests were performed to the structure, device and mobile application using the created prototype.

Structural Tests. The structure of the prototype was built in wood, with a plywood cover on the top part. Wood minimizes costs, when compared with the selected product materials, and can be reused in future projects. The bottom, pillar and top parts were attached with metal connectors. Figure 5b shows the wooden structure of the prototype. The structure of the prototype was modelled and tested with the help of Autodesk Fusion 360 software. The team performed safety factor and stress load tests. The force applied was 600 N, corresponding to the average force a person applies when pushing an object [7], resulting in a safety factor of 5.4 and an equivalent stress of 29.7 MPa.

Device Tests. The first test focused on the NFC communication. The program initializes the NFC module and establishes the Wi-Fi connection, using the provided network name and password. Then, waits for the scanning of an NFC enabled smartphone. After scanning, the program connects to the remote server and sends a HyperText Transfer Protocol (HTTP) request to update the remote database. Once updated, the server answers with a 200 status code (successful). The server application, developed in Java with the Spring framework, is responsible for updating the number of attendees in the previous and current zone of the user. The team faced some obstacles to obtain the scanner data on the phone. The problem was that the NFC module is a reader (it reads the input from the phone but the phone does not recognize it). It was solved through double scanning. The first scanning is performed between the smartphone and NFC module to inform the ESP32 about the user arrival at the zone. The second one, between the NFC tag (containing the zone number) and the smartphone, uses the obtained zone number to retrieve the current number of people from the remote server.

Mobile Application Tests. The mobile application was developed with Android Studio. Figure 5c presents the home screen of the application. The home screen depicts the number of people in the current zone. Whenever the user scans the NFC tag with the smartphone, the current zone number and number of people in the area are displayed. Besides this data, the attendee can pick an activity from the home screen. After picking the activity, the user is redirected to the map presenting the crowd density, points on the map of the festival and paths to take. The map-based interface

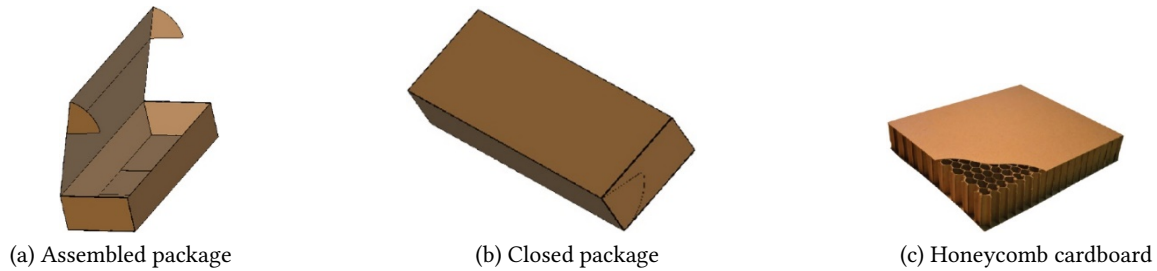


Figure 4: Packaging

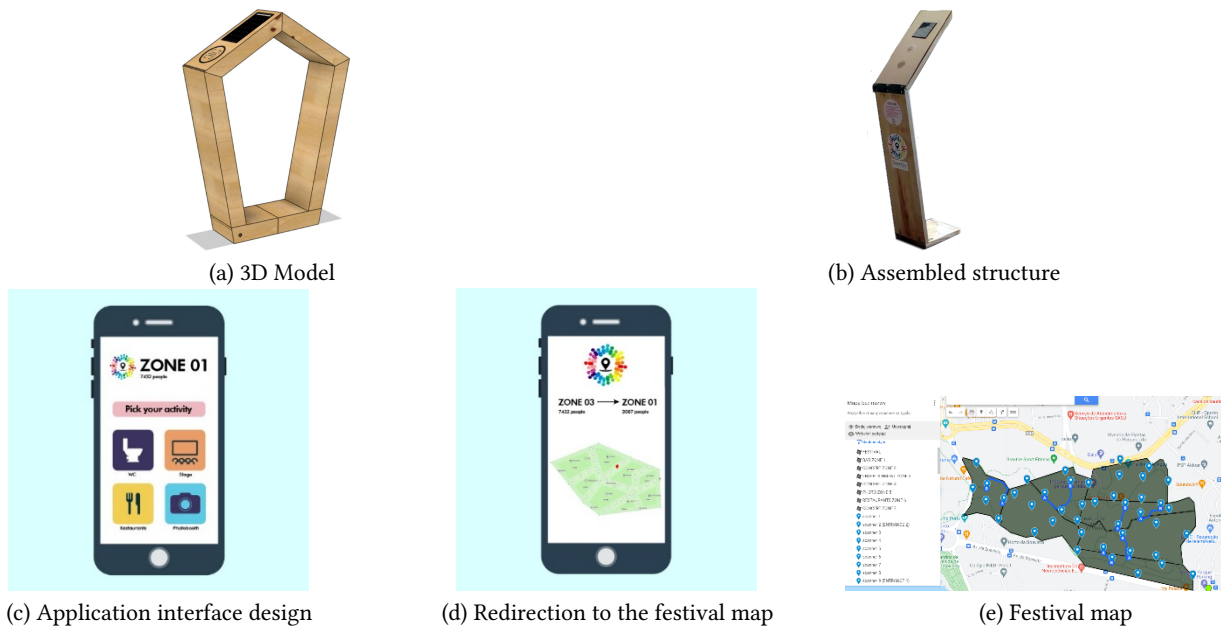


Figure 5: Prototype and Mobile Application

design is presented in Figure 5d. The festival map was created as a layer over a Google map. The team selected the Parque da Cidade in the city of Porto with an area of 55.5 ha, as determined through the map (Figure 5e). The application first checks if the smartphone has the NFC enabled. If not, a prompt displayed with the information “NFC disabled. Please turn it on”. Next, the tag scan returns the zone number and the application requests the zone data from the remote server. Finally, the user can click on any activity button to be redirected to the map-based interface.

4 DISCUSSION

ScanGo supports the organization of outdoor events using the ScanGo device and mobile application. The tests performed allowed the identification of several limitations that should be addressed.

The interaction between the scanner and the application can be refined. Currently, the application has to be opened and subsequently scanned for the user to receive information. Apart from the Android version, there should also be an iOS version of the application. In case scanners are deployed individually instead of

back-to-back, their stability needs to improve. The LED can be used not only to indicate the device is working, but also to show the scanning result by blinking or changing color.

5 CONCLUSION

The initial goals were achieved and even surpassed. The wooden prototype was built and two dedicated applications were created, namely the Android mobile application and the server application. After several tests, the ScanGo prototype worked as expected. Teamwork, planning and communication were the key to the success of this project. The team designed ScanGo, a solution for crowd orchestration consisting of an outdoor scanner, mobile and server applications and packaging. The team also delivered a report, an initial version of this paper, a poster, a leaflet, a flyer, a user manual, videos and presentations as well as maintained the project wiki.

This learning experience contributed to develop hard and soft skills and make new friends. Below are the testimonies left by the team members regarding their EPS@ISEP experience.

- “I was sceptic before applying for this project mainly because of the global pandemic and the unstable situation I thought we were going to face here. I have faced my fears and doubts and coming was the best decision I could possibly make. Here I learned many new skills, improved my English level from interacting with international students and gained a lot of knowledge in working as a team.” – Cristian.
- “At first I was not sure to be part of this European project. I think it was a good experience for the simple fact that it forced me to leave my comfort zone to developed important complementary skills for the future. Teamwork made me grow as a person. Overall, it was worth it.” – Bruno.
- “I really wanted to take part in European Project Semester since it enables students to gain new skills and work with international peers from different fields of study. This experience met my expectations. The project helped me to get out of my comfort zone as I needed to learn about programming, materials and marketing. I had an opportunity to discover and explore the fields that I was never thinking about. EPS broadened my mind to many aspects and I am glad that I had an opportunity to develop both myself and my competencies.” – Maja.
- “The European Project Semester was a positive experience for me. The activities accompanying the project allowed me to gain new, additional knowledge outside my area of specialization. Thanks to working with people from other nationalities I improved my English and communication skills. The project was very well organized with deadlines for tasks. I am glad that I had the opportunity to participate in the project.” – Ewa.
- “At first I was afraid to spend my whole Erasmus online because of the pandemic, but it quickly got better and I was able to interact with colleagues from different countries, improve my English and complete a project from start to finish. Moreover, I was able to discover new facets of teamwork and

develop new skills in different areas. I am glad I was able to participate in the European Project Semester.” – Bleuenn.

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